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Contract Nobs-90267
Project Serial No. SR001-03-01, Task 606

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DEVELOPMENT OF NONFLAMMABLE HYDRAULIC FLUID

BUREAU OF SHIPS
Department of the Navy
Washington, D. C.

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February 1, 1965 to April 1, 1965

DEVELOPMENT OF NONFLAMMABLE HYDRAULIC FLUID

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FOREWORD

This report was prepared by the Research and Development Department of the American Oil Company under U.S. Navy, Bureau of Ships Contract Nobs-90267, Project Serial No. SR001-03-01, Task 606. Covered is work done from February 1, 1965 to April 1, 1965. The work was administered under the direction of the Chief, Bureau of Ships, Code 634A, with Mr. E. C. Davis as technical monitor.

ABSTRACT

The objective of this study is the development of a water-base hydraulic fluid which (1) yields a fire-resistant non-aqueous residue, (2) is compatible with materials of construction and sea-water contamination, (3) satisfactorily lubricates shipboard pumps, (4) presents no unusual storage or handling problems, and (5) exhibits no toxicological hazards under conditions of use.

A fluid has been developed which appears to have the desired properties. It contains about 20% of a thickener prepared by chlorophosphonating polyethylene (12,000 m.w.) followed by hydrolysis and neutralization with potassium hydroxide. Potassium bis-hydroxymethyl phosphonate (25%) and potassium molybdate (1%) are added as pour depressor and corrosive inhibitor respectively. This fluid performs satisfactorily in a Vickers Vane pump run at 150°F and 1000 psi and shows satisfactory viscosity and pour-point properties. Other tests are being carried out.

DEVELOPMENT OF NONFLAMMABLE HYDRAULIC FLUID

INTRODUCTION

Two types of fire-resistant hydraulic fluids are being used in aircraft-carrier systems. The fluid used in hydraulic catapults is a mixture of water, glycol, polyglycols, and additives. An aromatic phosphate ester fluid is used in aircraft elevators. Because of the complexity of submarine hydraulic systems, both of these fluids have serious shortcomings. The water-glycol fluids are incompatible with sea water, are relatively poor lubricants for heavily loaded bearings, and are corrosive to aluminum. In addition, loss of water results in the formation of flammable residues. Because of fluid-leakage problems, phosphate esters cannot be used in submarines.

A satisfactory water-base fluid for shipboard hydraulic-system use is needed. For the uses envisioned, fire resistance in both the finished fluid and the non-aqueous residue is of prime importance. In addition, the fluid must be capable of lubricating shipboard hydraulic pumps, be compatible with materials of construction and with 10% sea-water contamination, and present no unusual handling and storage problems. The fluid should be formulated to minimize toxicity hazards under conditions involving long periods of continuous exposure. Fluid residues should be removable by flushing with water.

In this study, the general approach consists of the synthesis and evaluation of water-soluble thickening agents which exhibit satisfactory fire-resistant properties. Development of thickening agents which allow formulation of a fluid having the desired fire-resistance, viscosity, and shear-stability characteristics will be followed by development of additives where necessary to impart satisfactory lubricating ability, oxidation and corrosion resistance, pour point, resistance to stable foam formation, and compatibility with sea water. When sucess, or near-success in the development of an appropriate thickening agent is indicated, it will be necessary to determine the toxicological hazards which may result from use of the fluid.

EXPERIMENTAL

The current program on non-flammable hydraulic fluids is aimed primarily at the formulation of a satisfactory fluid using salts of hydrolyzed, chlorophosphonated polyethyiene as a thickener. Work on the development of satisfactory pour depressors and corrosion and wear inhibitors continues.

Chlorophosphonation of Polyethylene - Numerous chlorophosphonations of 12,000 m.w. polyethylene have been carried out using the procedure presented in Bimonthly Report No. 2. After hydrolysis and aging of the reaction products, fluids were prepared for testing in a Vickers Vane pump and for other studies.

Viscosity Properties - Data presented in Bimonthly Report No. 5 indicated that fluids being studied at that time showed considerable viscosity instability and did not meet the viscosity requirement at 25°F. These fluids, and all discussed in earlier reports, were neutralized to a pH of about 8 using pH paper. Tests using a pH meter, however, showed pH values of about 10. With these fluids, it has been found that there is a fairly constant difference of 2 pH units (in the range of 5 to 10) between the results using indicator paper and the pH meter. Fluids neutralized to a pH of 8.0 (by pH meter) do not exhibit the viscosity instability properties of more-highly-alkaline products.

Pump Tests - Five Vickers Vane Pump tests have been carried out since the last report. In every test, thickener prepared from 12,000 m.w. polyethylene and neutralized with potassium hydroxide was used. Tests were carried out at 1000 psi. and 150°F. Results may be summarized as follows:

Ref. No.	Fluid (Water and Thickener +)	Results
1	30% Glycerin 1% Potassium chromate pH - 8 (paper) 10 (meter)	10.5 gm. ring wear after 72 hours. Large viscosity increase after 24 hours.
2	Used fluid from #1 + 1.5% Aque-Dag colloidal graphite	10.4 gm. ring wear after 72 hours. Large viscosity increase.
3	25% Ethane phosphonic acid 1% Molybdic acid pH - 7.4 (meter)	3.4 gm. ring wear after 72 hours. Slight increase in viscosity because of water evaporation.
4	Used fluid from #3. Fluid neutralized to pH - 9.4 (meter)	2.2 gm. ring wear after 90 hours. Slight increase in viscosity because of water evaporation.
5	25% Bis-hydroxymethylphosphonic acid 1% Molybdic acid pH - 8.0 (meter)	0.34 gm. weight loss on ring after 74 hours. Slight increase in viscosity because of water evaporation.

Complete data on the last test are:

Test Hours	74
Weight Loss (gms.)	
End Plates	nil
Rotor	0.030
Ring	0.338
Vanes	0.003
Viscosity (SSU at 150°F)	
Initial	117.7
Final	148.4

Corrosion tests at 150°F using steel, copper, aluminum, zinc, and silver braise test strips in the same samples are being run. Weight-loss data will be reported later. After four days, there are no visual indications of excessive corrosion.

A second sample of fluid having the same composition of that tested in run No. 5 showed:

Viscosity at 150°F	110.6 SSU 22.9 cs.
Viscosity at 25°F	2922 SSU 634 cs.
Pour (°F)	-50

These data indicate that no problems should arise in meeting viscosity and pour-point requirements. Other inspections are being obtained.

FUTURE PROGRAM

A large batch of fluid having the composition of that used in pump test No. 5 is being prepared. A pump test will be run on a part of the fluid. The remained will be used for inspections and other tests, including toxicity studies. Two quarts will be reserved to fulfill the requirements of the contract.